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Technological profile of beef cattle farms in Brazilian biomes

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Summary

Technological profile of beef cattle farms in Brazilian biomes

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Abstract - Beef production in Brazil is based on a great diversity of production systems. Despite the increasing in recent years, productivity is still low, giving space to technological intensification. The present study used special tabulations of Brazilian Census of Agriculture - 2006 to describe the predominant beef cattle systems, with emphasis on technological variables. Factor analysis and clustering techniques were used together, by biome, covering a universe of 124 thousand farms, 94 million heads of cattle and 86 million

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hectares of pasture. The results highlight the productivity differences among regions and farms, outlining the farm profiles per biome. Such results can be helpful to support research and technologies transfer, as well as public policies aimed to the sector.

Index terms: Farming systems, farm typology, multivariate analysis, factorial analysis, cluster analysis.

Perfil tecnológico dos estabelecimentos agropecuários produtores de bovinos de corte nos biomas brasileiros

Resumo - A produção de bovinos de corte no Brasil se baseia em sistemas de produção profundamente heterogêneos. Apesar da média nacional de produtividade vir aumentando nos últimos anos, ela ainda é baixa e existe grande espaço para a intensificação tecnológica do setor. O presente trabalho empregou tabulações especiais de dados de estabelecimentos agropecuários produtores de bovinos de corte, levantados no Censo Agropecuário 2006, para mostrar a variabilidade da pecuária de corte no país, conforme as características da produção e com ênfase em variáveis tecnológicas. Foram usadas em conjunto técnicas de análise fatorial e de agrupamentos e os estudos foram conduzidos por bioma, cobrindo um universo de 124 mil estabelecimentos, 94 milhões de cabeças de bovinos e 86 milhões de hectares de pastagens. Os resultados evidenciam a desigualdade da produtividade entre regiões e produtores e traçam os perfis dos agrupamentos de produtores por bioma. Resultados como os encontrados podem servir como ferramentas de apoio à orientação de ações de pesquisa, de transferência de tecnologias e de políticas públicas voltadas ao setor.

Termos para indexação: Sistemas de produção, tipologia de fazendas, análise multivariada, análise fatorial, análise de cluster.

Introduction

The Brazilian cattle sector, which historically has developed by moving the agricultural frontier and using land depleted by crops (Barbosa et al., 2015), also shows important gains in productivity. According to Dias-Filho (2014), from 1975 to 2006 the average stocking rate increased by 92%, from 0.62 to 1.19 heads/ha. It happened all over the country, mainly on the North and Central regions, where the increasing was above 200%. Despite this advance, the beef cattle productivity is still low, thus offering opportunities for technological intensification (Dias-Filho, 2014; Wedekin et al., 2017). For Barbosa et al. (2015), the livestock industry lives a no return intensification process, since its expansion is limited by rigorous policies to combat deforestation, besides competing with soybeans and other crops. In addition, the sector has been increasingly demanded with respect to food quality and security, environmental conservation and social responsibility.

Forecasts indicate that the Brazilian beef sector will keep growth rates in the next decade (OECD-FAO..., 2019). Beef production will achieve 11.4 million tons in 2027, a growth of 20.5% in relation to the 9.5 million tons in 2017 (Projeções..., 2017). The exports, according to the USDA (Estados Unidos, 2017), will increase from 1.95 million tons in 2017 to 2.65 million tons in 2026, making Brazil the first beef exporter. Such progress and its striking figures will be leveraged by productivity increasing (Projeções..., 2017).

Despite the productivity gains, Brazilian beef production systems are very heterogeneous (Fasiaben et al., 2013; Wedekin et al., 2017), running side by side modern and rudimentary production systems. According to Wedekin et al. (2017), in extensive production systems, land and cattle are often seen as inheritance assets, as previously found by Costa and Rehman (1999).

Special tabulations of the Brazilian Census of Agriculture – 2006, organized and carried out by Brazilian Institute of Geography and Statistics (IBGE), show the size of Brazilian beef sector[1] in that year: 117 million head, area of

[1] The Brazilian Census of Agriculture – 2006 (IBGE, 2012) identified the purpose of raising cattle (beef, milk or traction) only in farms having 50 heads or more of cattle.

pasture close to 104 million hectares and 312 thousand farms[2] engaged in the activity (IBGE, 2012).

The size of Brazil's beef cattle production, spread throughout the national territory, shows how difficult it is to know the diversity of production systems practiced by farmers. According to Alvarez et al. (2018), agricultural typologies help to understand the complexity of agricultural systems, providing a simplified representation of the systems diversity, organizing farms into homogeneous groups.

Landais (1998) defines a type as an abstract generic model that determines the characteristics of a group of objects. The term "typology" designates: a) the science of type-making, designed to help analyze a complex reality and sort objects that, although different, are of one type (farms, for example); and b) the set of types resulting from this procedure (the agricultural typology of a particular region, for example).

Typologies of agricultural systems have been used for different purposes, with different geographic coverage. The studies range from analyses of specific problems in reduced areas - such as the typology elaborated by Teixeira and Silva (2007), which focused on cattle ectoparasitoses in a particular Brazilian county - until the classification of farms in a country or continent - such as the typology of US farms developed by the Economic Research Service (Estados Unidos, 2000) and the Types of Farming (TF) in the European Union, developed by the European Commission of the Farm Accountancy Data Network (FADN)[3]. Typologies are generally conditioned by their objective, the nature of the available data, and the farm sample (Perrot; Landais, 1993; Madry et al., 2013; Alvarez et al., 2018).

The main objectives of the typologies described in the literature are: a) technical-economic orientation to support extension actions, technical assistance and technology transfer, according to the different types (Teixeira;

[2] IBGE uses the following definition of "agricultural holding", for the data collection unit of the CHensus of Agriculture - 2006: "It is any production unit used, totally or partially, for agriculture, forestry and aquaculture activities, drived by a single administration, be it a farmer or an administrator. Regardless of its size, legal form or location in urban or rural areas, with the objective of producing for subsistence and/or for sale, thus constituting a survey unit." (IBGE, 2012, p.41). To benefit the fluency of the English text, in this work "farm" was used as a synonym of "agricultural holding".

[3] Available at: <http://ec.europa.eu/agriculture/rica/diffusion_en.cfm#sg>.

Silva, 2007; Daloglu et al., 2014; Goswami et al., 2014; Kuivanen et al., 2016); b) support the formulation of public policies and research priorities (Estados Unidos, 2000; Zorom et al., 2013; Jelsma et al., 2017); c) analysis of strategies to adapt to external shocks, vulnerability and food security (Zorom et al., 2013; Douxchamps et al., 2016; Lopez-Ridaura et al., 2018); and d) provide basic data to support simulation, exploratory studies and scenarios building (Landais, 1998; Jahel et al., 2017; Robert et al., 2017).

Related to technical-economic orientation to support the formulation of public policies, research priorities, extension actions, technical assistance and technology transfer, typologies are important because they enable the definition of so-called “recommendation domains”, that are defined as: a group of relatively homogeneous farmers, with similar circumstances, for whom it is possible to make similar recommendations (Planning…, 1988). Regarding the support for public policies formulation, in the Brazilian case a good example of the use of typologies is the study carried out by FAO / INCRA. Using data from the Agricultural Census - 1996, this study characterized family farming groups and proposed different subsidized credit programs (PRONAF) for each of them (Bianchini, 2010, 2015).

Studies on typologies have been conducted on the five continents addressing the differentiation and characterization of several agricultural systems, for example: a) in America, Daloglu et al. (2014) analyzed US corn belt farmers; Faverin and Machado (2019), cow-calf systems in the pampa of Argentina; Alemu et al. (2016), beef production in Canada; Miguel et al. (2007) and Sales et al. (2016), beef cattle in Rio Grande do Sul and dairy cattle in the Campina Grande microregion in Paraíba in Brazil; b) in Europe, Gelasakis et al. (2012) studied dairy sheep in Greece; Andersen et al. (2007), the management and environmental performance of EU farms; c) in Oceania, Lacoste et al. (2018) analysed agrarian systems in Australia; d) in Asia, Goswami et al. (2014) worked with agricultural systems in West Bengal in India; Jelsma et al. (2017, 2019), with oil palm smallholders in Riau, Indonesia; and e) in Africa, Kuivanen et al. (2016) developed the typology of smallholder production systems in northern Ghana.

The objective of the present study was to know the different production systems practiced by beef cattle farmers in Brazil, to support research and development, transfer of technology and public policies. For this purpose, farms

were classified into homogeneous groups according to their production characteristics, with emphasis on technological variables. In the literature related to the typology of agricultural systems, there are few works with the scope that this study intended to achieve. Using farm data from the Brazilian Census of Agriculture - 2006 (IBGE, 2012), it included more than 124 thousand farms (40% of the total beef cattle farms), 94 million heads (81% of the beef cattle) and 86 million hectares of pasture (83% of the beef cattle area), in the six Brazilian biomes.

Material and methods

Data processing

Taking data from the Brazilian Census of Agriculture – 2006 (IBGE, 2012), farms with beef production as main purpose[4] were allocated in the corresponding biome, making compatible the biomes geography and the sectorial census maps.

Despite the generalized presence of cattle on Brazilian farms, it was in the interest of this study to restrict the analysis to a commercial scale. After discussion in a technical panel with specialists in beef cattle production, some limits were established, respecting the biome characteristics: farms with 100 heads or more in Caatinga; 200 heads or more in Amazônia, Cerrado, Mata Atlântica and Pampa; and 500 heads or more in Pantanal. Such “thresholds” are supported by a number of studies that required defining a representative herd size. In a study which described Cerrado’s improved beef production systems, the herd size ranged from 1,269 (the modal system) to 3,208 heads of cattle (Corrêa et al., 2006). For the State of Pará, with the largest beef herd of the Amazônia biome, the modal herd size was 2,707 heads (Corrêa et al., 2005). In Pampa, the modal system was defined with 1,086 heads (Costa et al., 2005). Economic results of beef cattle systems are reported annually by

[4] In the scope of bovine farming, the Census of Agriculture - 2006 had as a special feature the application of a detailed questionnaire only in farms that had more than 50 heads of cattle at the reference date (12/31/2006). In farms with 1 to 50 head of cattle, this level of detail of cattle production was not performed.

ANUALPEC (Pecuária..., 2019), defining respectively 5,000 and 500 animal-units as herd sizes which self-benefit or not from “economies of scale”.

This selection is highly representative, encompassing the following shares of beef cattle in the biomes: 88% for Cerrado, 86% for Amazônia, 77% for Mata Atlântica, 82% for Pampa, 95% for Pantanal and 81% for Caatinga.

Finally, several filters were used to exclude inconsistent data and outliers. Giving the importance of stocking rate, values above the limit[5] defined by Q3 + 3 x (Q3 - Q1) were considered improper (outliers), except for feedlots. After this additional filter, around 124 thousand farms, 94 million head of cattle and 86 million ha of pasture remained as the universe to apply the typology.

The data processing was done by IBGE, in order to guarantee the confidentiality of the informants.

Variables selection

To typify the farms, five dimensions were established based on the following logical reasoning (Table 1). Given a scale that defines the resources availability (*Business size*), land can be used in several ways, from a simplest monoculture to a diversified portfolio (*Land use and diversification*). The present study always included beef cattle, in some degree (*Economic importance of beef production*). By its turn, this activity combines different phases (*Main activity developed*) which can be developed under different intensification and technological levels (*Technological level and intensification*).

“Business size” was embodied by herd numbers, since beef cattle was the focus of the present study. “Land use and diversification”, “economic importance of beef production” and “main activity developed” were represented performing straightforward calculations. Conversely, “technological level and intensification” demanded special attention, since they are more complex and, in some sense, interconnected concepts. Stocking rate and proportion of animals in feedlots directly represent intensification, but this can also be seen as a result of using technology.

[5] Q1 is the first quartile and Q3 the third quartile of the distribution of values.

Table 1. Variables used to tipify beef cattle farms in Brazilian biomes.

Dimensions and variables	Amazônia	Cerrado	Mata Atlântica	Pantanal	Pampa	Caatinga
Main activity developed						
1. Percentage of farms having cow-calf	x	x	x	x	x	x
2. Percentage of farms having rearing	x	x	x	x	x	x
3. Percentage of farms having finishing	x	x	x	x	x	x
4. Percentage of cows in the herd	x	x	x	x	x	x
5. Percentage of steers in the herd					x	
Technological level and intensification						
6. stocking rate (AU/ha)	x	x	x	x	x	x
7. Percentage of farms using feed suply	x	x	x	x	x	x
8. Percentage of farms using pastures fertilization	x	x	x	x	x	x
9. Percentage of cows inseminated	x	x	x	x	x	x
10. Percentage of cattle in feedlots	x	x	x	x	x	x
11. Percentage of farms that have animals traced				x		
12. Percentage of farms using advisory services	x	x	x	x	x	x
Land use and diversification						
13. Percentage of pasture area (by used area)	x	x	x	x	x	x
14. Percentage of natural pastures area (by total pastures area)				x	x	x
15. Percentage of degraded sown pastures area (by total pastures area)				x	x	
16. Percentage of forages for cutting area (by used area)					x	x
17. Percentage of total crops area (by used area)	x	x	x			x
18. Percentage of total permanent crops (by total crops area)					x	
19. Percentage of temporary crops (by total crops area)					x	
20. Percentage of planted forests area (by total used area)	x	x	x		x	x
Economic importance of beef production						
21. Percentage of product gross value coming from beef	x	x	x	x	x	x
Business size						
22. Total beef cattle per farm (UA / farm)	x	x	x	x	x	x

A broad review of the concept of intensification was carried out by Ruiz-Martinez et al. (2015), identifying several indicators of agricultural intensity. Among others, they highlighted technologies/labour intensity, use of mineral and organic fertilizers and grazing intensity, thus corroborating the choice made here. The choice can also be corroborated by Madry et al. (2013), who made a critical approach of the typology methods used in pasture-based systems, showing the relevant variables for the systems classification. Analyzing 18 studies focused on typologies of animal production systems, developed in several countries of Europe and South America from 2003 to 2012, these authors report that the main technical and economic variables found are: farm acreage, herd size, stocking rate, workforce, feed supply and productivity; income, expenses and margins.

The dimensions described above were then represented by a set of 22 variables selected from the Census questionnaire, after hearing experts on regional aspects of beef production (Table 1).

Statistical analysis

Data were treated by biome, using factor and cluster analyses. Using the first, variables strongly correlated were replaced by a set of factors, and those which more contributed to explain the data variability remained to perform the cluster analysis. This technique allocates the study units into mutually exclusive groups, such that the characteristics are homogeneous within the groups and heterogeneous between them. Further details of the statistical procedures can be found in Fasiaben et al. (2013). The methodological choice is supported by the international literature (Köbrich et al., 2003; Madry et al., 2013; Goswami et al., 2014; Jelsma et al., 2017; Weltin et al., 2017).

Results and discussion

Through the factorial analysis, the variables described were reduced to eight composite indicators (common factors). This number of factors was based both on the marginal contribution to explain the total data variability and

on the relevance to represent a behavior not observed in the data structure. The eight common factors explained the following percentages of the total variability of the original variables: 67.1% in Amazônia; 68.7% in Cerrado; 70.1% in Mata Atlântica; 65.8% in Pantanal; 59.3% in Pampa and 62.2% in Caatinga.

The structure of correlations between variables supported the interpretation of each factor (Appendices 1 to 6). Those with the greatest discriminatory power, common for most biomes, are described below:

1. Factor related to diversification, with crops exceeding the participation of beef in the total gross value.
2. Factor that emphasizes the cow-calf activity, with the higher percentage of cows in the herd.
3. Factor related to herd size (production scale).
4. Factor associated to technology, where feed supply, pastures fertilization and advisory services present the higher correlations.
5. Factor that emphasizes the rearing and finishing activities.
6. Factor related to stocking rate.
7. Factor which highlights forest cultivation.
8. Factor related to the percentage of feedlot cattle.

In Pantanal, Pampa and Caatinga, where natural pastures are prevailing, a factor showing strong correlation with this variable was also observed. In Pantanal, such factor also emphasizes the stocking rate, but in opposite direction, since these variables present negative correlation. In Pampa and Caatinga, a factor related to forage for cutting was also important.

The cluster analysis used Ward's minimum variance method[6] (Ward, 1963). The selection of number of groups was based on their discriminatory power to explain the total variability of the common factors, besides the analytical feasibility of the resulting combinations. In other words, the aim was to define the smallest number of clusters that represent the variability of the factors, taking into account the production patterns in the territory.

[6] Ward's method seeks to create homogeneous groups in such a way that the variance is minimal within these and maximum among them.

Eight clusters have been selected for each biome, explaining the following percentages of the total variability of the eight common factors (semipartial R^2): 52.7% for Amazônia; 55.3% for Cerrado; 51.42% for Mata Atlântica; 49.5% for Pantanal; 42.4% for Pampa and 47.7% for Caatinga. Finally, it should be noted that, after discussion with beef cattle experts in each biome, the clusters found were considered compatible with the regional reality.

The technological levels found in the farms were very different, between the biomes and within each biome. However, given the particularities of soil and climate, it makes no sense to compare technological levels between biomes; therefore, only differences found within each biome were taken into account. For example, low-tech systems in Mata Atlântica are not comparable to low-tech systems in Pantanal, the latter characterized by extensive systems, fully explained by the natural conditions of the biome.

The clusters description, including main activity, diversification and technological levels, as well as the averages for the classificatory variables, is presented in Appendices 7 to 12.

Although the eight groups explain a significant portion of the data variability, get a better understanding of the technological patterns prevailing in the country would require a too complicated analytical effort. To overcome this problem, a second grouping stage was applied to the farms, defining three technological levels for each biome: “low”, “intermediate” and “high”.

To do so, the clusters were “grouped” according to the average of the standard values[7] of the variables representing technological level, namely: a) Stocking rate; b) Percentage of farms using feed supply; c) Percentage of farms using pastures fertilization; d) Percentage of farms using crops for pasture recovering; e) Percentage of cattle in feedlots; and f) Percentage of farms using advisory services. Clusters with mean values lower than -0.25 were classified as low technology; those with mean values between -0.25 and 0.25 were classified as intermediates; and those with mean values above 0.25 were classified as high technology clusters. These new groupings were checked by experts, have been considered consistent when faced with regional reality.

[7] The standardized value was calculated as the the ratio between the deviation from the biome average and the standard deviation of the respective variable.

After the analyses, the frequency of technological levels was represented spatially, by biome, using a Geographic Information System (GIS). For this, the ArcGis 9 software was used.

Technological levels by biome

Cerrado

The Cerrado is the second largest (24% of Brazilian territory) and the main biome with regard to beef production. Human occupation has changed it a lot, as a result of opening areas for agricultural and livestock production, only surpassed by the changes in Mata Atlântica. It is estimated that, by 2008, the Cerrado biome had already lost 47.84% of the 204 million hectares of its original vegetation. (Brasil, 2018a).

In 2006, 33% of Brazilian beef farms were located in Cerrado, accounting for 43% of pastures and 40% of beef cattle in Brazil. Considering the farms having 200 heads or more of the Cerrado Biome that composed this analysis, the average pasture area per farm was 812 ha, the second largest among the biomes, and the average herd was 597 animal-units[8] (AU). The average stocking rate in Cerrado was 0.74 AU/ha. The main characteristics of the Cerrado clusters are presented in Appendix 7.

The typology evidenced the coexistence of extensive and intensive beef cattle systems, besides relevant differences in the degree of specialization. Such degree was determined by the IBGE as follows: “After finding out the revenues of all farm enterprises, the main activity is defined as the one with the highest revenue value. If the enterprise revenue exceeds 66% of total revenue, the farm is considered specialized, by the contrary is considered diversified” (IBGE, 2012, p. 93).

Clusters with predominance of specialized farms have as main characteristics: a) grassfed, full cycle (cow-calf, rearing and finishing) systems, selling finished cattle but also yearlings and stocker steers, running an in-

[8] Information on the weight of animals and “Animal Units” was not collected in the Census of Agriculture – 2006 (IBGE, 2012). IBGE calculates the “Animal Units” in order to standardize categories of animals, which may vary according to species, sex, age, weight and geographical region. Generally speaking, a cow weighting 450 kg corresponds to one animal-unit.

termediate technological level (Cluster 4); b) grassfed rearing and finishing systems, low technological level (Cluster 3); c) cow-calf systems, low technological level (Cluster 5); and d) large feedlots, with high technological level (Cluster 7). Farms not specialized on cattle raising used land for pastures, crops or forestry (Clusters 1, 2 and 6). The diversified farms represented 13% of the total, 24% of the pasture area and near 28% of cattle, carrying out a grassfed full cycle production system. For these cases, the technological level could be considered high. The eighth cluster was not considered for being represented by only one farm. Table 2 shows the distribution of beef cattle farms and the beef cattle distribution, according to technological level, per Federation Unit (FU) of the Cerrado.

In Cerrado the intermediate technological level is prevalent, with the highest frequencies in terms of cattle and farms. The Paraná State (in its Cerrado portion[9]) and the Federal District had the highest proportion of cattle raised under “high technology”. However, it should be noted that these states hold the smallest herds in the biome. On the other hand, Maranhão and Piauí presented the highest percentages of cattle raised under low technology. As for the frequency of establishments, Paraná and Federal District keep the same condition, while Maranhão, Goiás, Minas Gerais, Tocantins and Piauí stand out for the use of low technology. These results are shown in Figure 1, which shows the spatial distribution of the predominant technological levels, and also the frequency of beef cattle farms in the Cerrado, by homogeneous microregion of IBGE.

[9] It is important to note that more than one biome can be present in the same Federation Unit.

Table 2. Distribution of beef cattle farms and cattle distribution according to technological level, by Federation Unit - Cerrado

Federation Unit(1)	Technological level												Total Farms	Total Heads
	High				Low				Intermediate					
	Farms	% of Farms	Heads	% of Heads	Farms	% of Farms	Heads	% of Heads	Farms	% of Farms	Heads	% of Heads		
Bahia	206	19	219,350	33	416	39	199,203	30	444	42	256,295	38	1,066	674,848
Distrito Federal	24	45	9,784	43	11	21	4,961	22	18	34	7,901	35	53	22,646
Goiás	1,571	11	2,678,317	25	6,305	45	3,862,561	36	6,191	44	4,277,175	40	14,067	10,818,053
Maranhão	318	17	276,589	26	903	47	450,501	42	704	37	355,749	33	1,925	1,082,839
Mato Grosso	717	13	1,866,992	33	2,257	39	1,453,612	26	2,75	48	2,273,384	41	5,724	5,593,988
Mato Grosso do Sul	1,165	11	3,971,604	32	3,828	36	2,935,869	24	5,535	53	5,556,088	45	10,528	12,463,561
Minas Gerais	1,061	15	953,816	22	2,999	43	1,533,328	36	2,941	42	1,763,475	41	7,001	4,250,619
Paraná	33	48	24,473	56	17	25	9,736	22	19	28	9,806	22	69	44,015
Piauí	55	18	22,665	18	119	40	50,284	41	127	42	50,268	41	301	123,217
São Paulo	652	29	432,100	33	773	34	397,336	31	859	38	468,923	36	2,284	1,298,359
Tocantins	374	9	434,635	16	1,813	42	1,005,280	36	2,13	49	1,347,583	48	4,317	2,787,498
Total	**6,176**	**13**	**10,890,325**	**28**	**19,441**	**41**	**11,902,671**	**30**	**21,718**	**46**	**16,366,647**	**42**	**47,335**	**39,159,643**

Source: Based on data from the Census of Agriculture – 2006 (IBGE, 2012).
(1) More than one biome can be present in a Federation Unit.

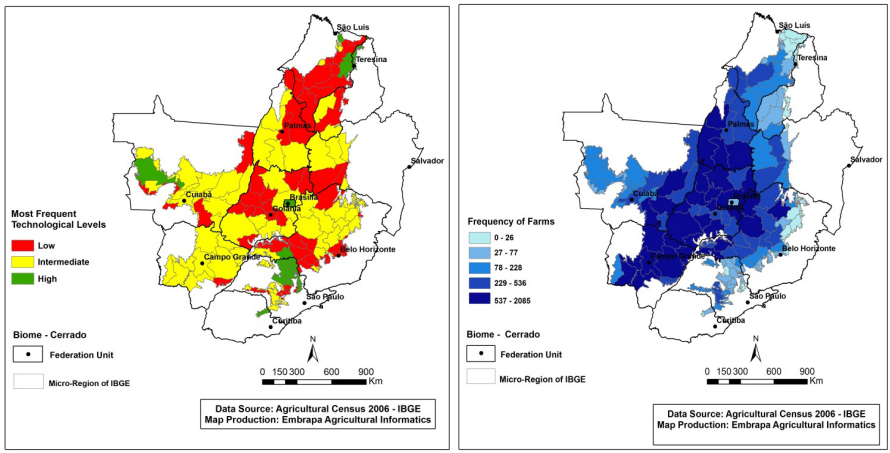

Figure 1. Most frequent technological levels in beef cattle farms and frequency of farms, by homogeneous microregion of IBGE - Cerrado.

Pantanal

The Pantanal biome, one of the world largest continuous wetlands, occupies just under 2% of Brazilian territory, and suffers direct influence of Amazônia, Cerrado and Mata Atlântica (Brasil, 2018b). According to the Biome Satellite Monitoring Program – PMDBBS (Brasil, 2018b), carried out with 2009 satellite images, the Pantanal retained 83.07% of its native vegetation cover, although it has been impacted by human action, mainly by agriculture, especially in the adjacent plateau areas of the biome. Cattle raising in Pantanal is mainly developed in extensive systems, exploring a selective grazing on native pastures and using natural water sources, with almost no external inputs (Embrapa Pecuária Sudeste, 2018).

In the Pantanal, full cycle, as well as rearing and fattening systems, are carried out in restricted highlands located in transition areas (Pantanal to Cerrado) which concentrate the planted pastures. The overlap of images related to geomorphology (Assine et al., 2016) and vegetation (Silva et al., 2007) supported the typology results.

According to the Census of Agriculture – 2006 (IBGE, 2012), in the Pantanal were located 1% of the Brazilian beef cattle farms, holding 7% of pasture areas and 3% of cattle.

The farms of Pantanal had the highest average values for pasture area (5,361 ha) and cattle (2,133 AU) in Brazil. In turn, its average stocking rate, of 0.4 AU/ha, was the lowest in the country. These values represent the averages of the farms having 500 heads or more that composed this analysis. The details of the Pantanal clusters are presented in Appendix 8.

Seven of the eight farm groups found out in the typology were considered specialized in beef production. Two of the groups, the predominant ones, developed cow-calf and rearing together, and cow-calf exclusively, presenting intermediate and low technological levels, respectively (Clusters 1 and 3). Three groups were characterized by full cycle systems, with a high technological level when compared to the biome average: a) large extensive farms, based on natural pastures and, on a smaller scale, on planted pastures with no fertilization (Cluster 4); b) farms with dominance of fertilized planted pastures (Cluster 6); and c) smaller farms combining full cycle beef systems with crops and forests, and agroforestry systems (Cluster 5). Also important are the farms dedicated predominantly to finishing or rearing-finishing, both on pastures, with an intermediate technology (Cluster 2).

The distribution of farms and cattle (in absolute value and percentage) according to technological level, per Federation Unit of the Pantanal Biome, are showed in Table 3.

Table 3 shows that the intermediate technological level predominates, when analyzing both, farms or cattle frequencies. In the Pantanal portion of Mato Grosso was the highest percentage of farms under “high technology”, while in Mato Grosso do Sul was the highest frequency of cattle under such condition.

Figure 2 shows the spatial distribution of the most frequent technological level, the intermediate one in the case, and its frequency by homogeneous microregion of IBGE.

Table 3. Distribution of beef cattle farms and cattle distribution according to technological level, by Federation Unit – Pantanal

Federation Unit(1)	Technological level												Total Farms	Total Heads
	High				Low				Intermediate					
	Farms	% of Farms	Heads	% of Heads	Farms	% of Farms	Heads	% of Heads	Farms	% of Farms	Heads	% of Heads		
Mato Grosso	63	16	268,439	31	139	35	276,530	32	200	50	329,391	38	402	874,360
Mato Grosso do Sul	107	13	1,033,579	36	187	23	440,845	15	534	64	1,383,676	48	828	2,858,100
Total	**170**	**14**	**1,302,018**	**35**	**326**	**27**	**717,375**	**19**	**734**	**60**	**1,713,067**	**46**	**1,230**	**3,732,460**

Source: Based on data from the Census of Agriculture – 2006 (IBGE, 2012).
(1) More than one biome can be present in a Federation Unit.

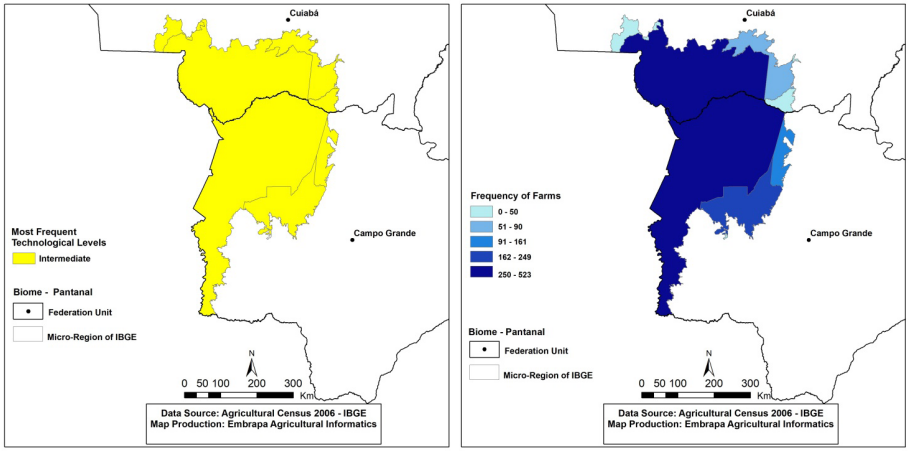

Figure 2. Most frequent technological levels in beef cattle farms and frequency of farms, by homogeneous microregion of IBGE - Pantanal.

Amazônia

Amazônia is the largest biome in Brazil, almost half the national territory. Although beef production in Amazônia has historically grown thanks to pastures expansion, this is now changing, with the intensification of production systems, induced by the market and the environmental demands, as well as more rigorous control of deforestation (Barbosa et al., 2015).

In Amazônia, at the time of the Census of Agriculture - 2006, 25% of farms raised beef cattle, keeping 24% of pastures and 28% of Brazilian cattle. Considering the farms having 200 heads or more of the Amazônia Biome that composed this analysis, the average pasture area of cattle farms was 701 ha, and the average herd was 615 UA, with a stocking rate of 0.88 AU/ha.

Six clusters were defined as the most representative of beef cattle production in the biome, whose details can be found in Appendix 9. The specialized clusters, following a decreasing order for the frequencies of farms and cattle, are: a) full cycle farms which also sale calves, low technology (Cluster 3); b) mainly finishing farms, on pastures, intermediate technology (Cluster 2); c) full cycle, low technology, smaller herds (Cluster 4); and d) large full cycle farms, high technology, purchasing of calves (Cluster 6). Clusters with diversified production were: a) full cycle systems in farms with similar areas for pastures and crops, showing also planted forests and agroforestry systems; high

Table 4. Distribution of beef cattle farms and cattle distribution according to technological level, by Federation Unit – Amazônia

Federation Unit(1)	Technological level												Total Farms	Total Heads
	High				Low				Intermediate					
	Farms	% of Farms	Heads	% of Heads	Farms	% of Farms	Heads	% of Heads	Farms	% of Farms	Heads	% of Heads		
Acre	164	12	195,422	20	942	71	625,477	65	225	17	147,311	15	1,331	968,21
Amapá	10	15	5,606	13	37	54	26,275	59	21	31	12,487	28	68	44,368
Amazonas	123	17	112,522	21	486	67	369,020	69	116	16	56,736	11	725	538,278
Maranhão	242	12	241,446	16	1,428	71	1,025,336	67	355	18	265,228	17	2,025	1,532,010
Mato Grosso	990	11	2,097,197	22	6,24	70	6,111,145	66	1,631	18	1,118,019	12	8,861	9,326,361
Pará	1,179	13	1,869,992	22	6,333	70	5,654,627	65	1,533	17	1,126,067	13	9,045	8,650,686
Rondônia	560	8	530,035	12	4,728	70	2,936,375	68	1,475	22	855,678	20	6,763	4,322,088
Roraima	80	20	57,813	25	262	67	141,897	61	51	13	32,898	14	393	232,608
Tocantins	85	10	195,838	19	564	64	634,497	62	227	26	191,131	19	876	1,021,466
Total	**3,433**	**11**	**5,305,871**	**20**	**21,02**	**70**	**17,524,649**	**66**	**5,634**	**19**	**3,805,555**	**14**	**30,087**	**26,636,075**

Source: Based on data from the Census of Agriculture – 2006 (IBGE, 2012).
(1) More than one biome can be present in a Federation Unit.

technology (Cluster 1); and b) full-cycle systems with a high technological level, with emphasis on pasture fertilization and advisory services (Cluster 5). Two clusters were not considered because they were represented only by two farms. Table 4 summarizes the distributions of farms and beef cattle (absolute values and percentages) according to the technological level, per FU of the Amazônia Biome.

Results point out that low technology predominated in Amazônia beef farms at all FU's, considering the frequency of both farms and cattle. At the high technological level, the best placed states were Roraima, Pará, Amazonas and Mato Grosso.

Figure 3 shows the most frequent technological levels adopted, by homogeneous microregions, and the frequency of such farms.

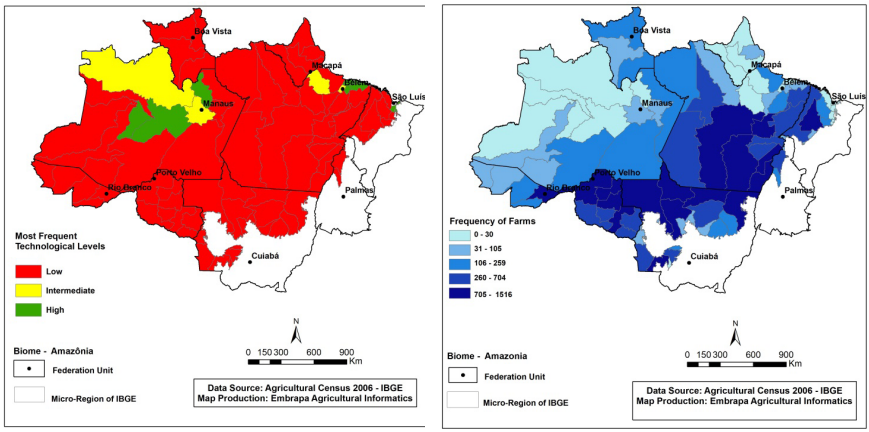

Figure 3. Most frequent technological levels in beef cattle farms and frequency of farms, by homogeneous microregion of IBGE - Amazônia.

Mata Atlântica

Mata Atlântica originally occupied 15% of the national territory, extending along the Atlantic coast, from Rio Grande do Norte to Rio Grande do Sul states, present in 17 Brazilian states. Nowadays, 60% of Brazilian population lives in such area, where is performed the most intense economic activity in Brazil. Extending along the Brazilian coast, this biome is very heterogeneous in terms of soil, topography and climate, allowing a wide range of farm enterprises: cereals and beans, cotton, coffee and sugar cane, forestry and fruit growing, besides dairy and beef cattle. Currently, less than 8% of the biome maintains its original characteristics, due to an intense exploration process that has been going on since the 16th century. Despite this fact, Mata Atlântica still keeps a great diversity of fauna and flora, nevertheless highly threatened. The United Nations Educational, Scientific and Cultural Organization (UNESCO) points this biome as a Brazilian priority for conservation actions[10].

According to the Census of Agriculture – 2006 (IBGE, 2012), in Mata Atlântica were located 29% of beef cattle farms, 16% of pastures used for beef production and 21% of the Brazilian beef herd. Considering the farms with 200 heads or more of the Mata Atlântica Biome that composed this analysis, the average pasture area was 417 ha, with an average herd of 435 AU and a stocking rate of 1.04 AU/ha. The main characteristics of Mata Atlântica clusters can be seen in Appendix 10.

Due to the biome diversity referred above, a great variety of beef production systems can be found. According to the IBGE criterion (IBGE, 2012, p. 93), 59% of beef farms were specialized, as follows: a) full cycle on pasture, intermediate technology (Cluster 4); and b) low-tech, pasture finishing systems (Cluster 2). The diversified clusters (41%) were: a) farms combining crops (area larger than that under pastures) and high-tech beef full cycle, besides agroforestry systems, high technology (Cluster 1); b) high-tech full cycle on pasture and larger herds (Cluster 3); c) cow-calf and rearing systems, low technological level (Cluster 5); d) finishing on pasture associated to feedlot and crops, high technology (Cluster 6); and e) farms combining planted forests and full cycle beef systems, high technology (Cluster 7). The eighth cluster was not considered to be represented by

[10] Available at: <https://www.embrapa.br/web/rede-ilpf/bioma/mata-atlantica>.

Table 5. Distribution of beef cattle farms and cattle distribution according to technological level, by Federation Unit – Mata Atlântica

Federation Unit(1)	Technological level												Total Farms	Total Heads
	High				Low				Intermediate					
	Farms	% of Farms	Heads	% of Heads	Farms	% of Farms	Heads	% of Heads	Farms	% of Farms	Heads	% of Heads		
Alagoas	143	34	70,965	37	159	38	68,697	36	119	28	50,111	26	421	189,773
Bahia	488	18	410,063	26	1,258	46	659,589	41	1,015	37	537,995	33	2,761	1,607,647
Espírito Santo	173	18	131,067	24	421	45	225,58	41	343	37	190,794	35	937	547,441
Goiás	98	16	128,861	30	233	39	142,53	33	271	45	162,569	37	602	433,960
Mato Grosso do Sul	608	25	1,660,339	56	943	39	694,768	23	863	36	605,185	20	2,414	2,960,292
Minas Gerais	863	20	638,889	29	1,904	45	853,224	39	1,481	35	686,327	32	4,248	2,178,440
Paraíba	17	34	6,525	29	25	50	11,928	54	8	16	3,734	17	50	22,187
Paraná	1,891	25	1,230,167	31	3,383	45	1,578,265	40	2,303	30	1,184,688	30	7,577	3,993,120
Pernambuco	69	29	30,785	30	114	47	46,935	46	59	24	24,911	24	242	102,631
Rio de Janeiro	161	15	126,543	23	476	44	213,905	39	445	41	203,131	37	1,082	543,579
Rio Grande do Norte	11	48	6,29	61	8	35	2,78	27	4	17	1,160	11	23	10,230
Rio Grande do Sul	293	28	127,271	31	320	30	120,828	29	439	42	167,336	40	1,052	415,435
Santa Catarina	340	30	144,299	33	327	29	113,589	26	465	41	175,506	40	1,132	433,394
São Paulo	1,422	22	1,334,178	34	2,577	40	1,313,780	34	2,378	37	1,222,398	32	6,377	3,870,356
Sergipe	55	19	21,747	17	109	38	48,971	39	120	42	53,801	43	284	124,519
Total	**6,632**	**23**	**6,067,989**	**35**	**12,257**	**42**	**6,095,369**	**35**	**10,313**	**35**	**5,269,646**	**30**	**29,202**	**17,433,004**

Source: Based on data from the Census of Agriculture – 2006 (IBGE, 2012).
(1) More than one biome can be present in a Federation Unit.

only one farm. Table 5 summarizes the farms and the beef cattle distribution, according to technological level, per FU of Mata Atlântica.

The low technological level prevailed in the farms, as it was for cattle, although the herd share among the technological levels was fairly balanced. Mato Grosso do Sul (in its Atlantic Forest portion) was an exception: despite the predominance of the intermediate technological level in the farms, most of its cattle falled in the category of “high technology”. The herd of Rio Grande do Norte also stands out for the high technological level, although little expressive in size.

Figure 4 shows the location of beef farms most frequent technological levels, as well as the farms frequency, by IBGE homogeneous microregions.

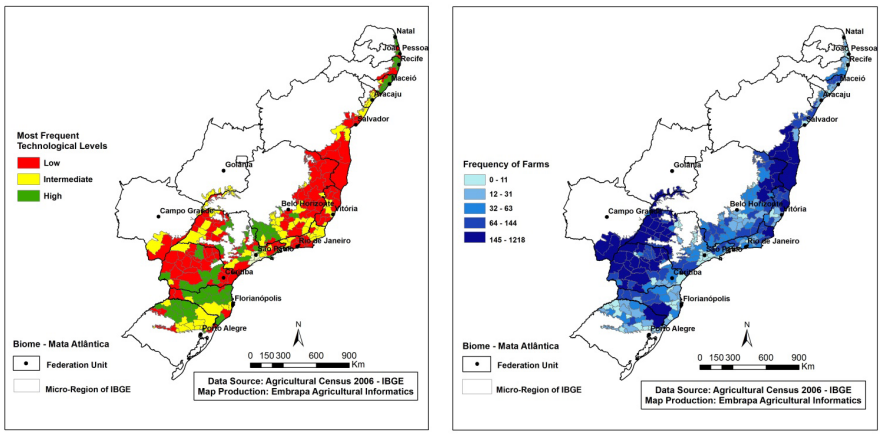

Figure 4. Most frequent technological levels in beef cattle farms and frequency of farms, by homogeneous microregion of IBGE - Mata Atlântica.

Pampa

In Brazil, the Pampa biome is restricted to Rio Grande do Sul (63% of the territory), and corresponds to 2% of the national territory. The native fields predominate, with a great diversity of flora - 450 species of grasses and 150 species of “Compositae” and legumes - and fauna. Livestock is dominant in the biome, but more recently, rice and eucalyptus become important economic activities. Such crops and pastures based on exotic species, have led to

a rapid decharacterization of Pampa landscapes, with only 36.08% of natural vegetation remaining in 2008 (Monitoramento…, 2010).

In 2006, Pampa accounted for 6% of farms, 6% of pastureland and 5% of the Brazilian beef cattle (IBGE, 2012). Considering the farms with 200 heads or more of the Pampa Biome that composed this analysis, the average pasture area of cattle farms was 623 ha, with an average herd of 473 AU and a stocking rate of 0.76 AU/ha. Eight clusters have been defined for this biome, and detailed information on them can be seen in Appendix 11.

All clusters grew crops, making up 13% of its area, in average. Only one was specialized in beef cattle (Cluster 1). Three were considered the most representative of Pampa cattle farms, always based on natural pastures: a) full cycle production, intermediate technology (Cluster 4); b) cow-calf and cow-calf plus rearing systems, low technology (Cluster 3); c) finishing under low technology (Cluster 1). Another cluster presented equivalent area with crops and pastures (46% and 48% of farm area, respectively), running full cycle and finishing systems, the later including cattle purchased in the market; high technology (Cluster 2). Three groups, less expressive, showed the highest technological levels: a) diversified farming, with crops, planted forests and agroforestry systems (Cluster 7); b) finishing including feedlots (Cluster 5); and c) full cycle systems with important presence of forage for cutting (Cluster 6). Cluster 8, which represents just over 1% of farms and herd, shows some divergence between technological level (high) and stocking rate (low), which may indicate an effort to recover degraded planted pastures. Table 6 summarizes the distribution of farms and cattle, respectively, according to technological level, per FU of Biome Pampa.

Table 6. Distribution of beef cattle farms and cattle distribution according to technological level, by Federation Unit – Pampa

Federation Unit(1)	Technological level												Total Farms	Total Heads
	High				Low				Intermediate					
	Farms	% of Farms	Heads	% of Heads	Farms	% of Farms	Heads	% of Heads	Farms	% of Farms	Heads	% of Heads		
Rio Grande do Sul	1,421	19	736,354	15	3,071	40	1,580,312	33	3,175	41	2,535,469	52	7,667	4,852,135
Total	**1,421**	**19**	**736,354**	**15**	**3,071**	**40**	**1,580,312**	**33**	**3,175**	**41**	**2,535,469**	**52**	**7,667**	**4,852,135**

Source: Based on data from the Census of Agriculture – 2006 (IBGE, 2012).
(1) More than one biome can be present in a Federation Unit.

Pampa is the only Brazilian biome contained in a single FU, the Rio Grande do Sul State. Most of the cattle and farms employed intermediate technology level. The “low technology” category was also relevant, as can be seen in Figure 5, which shows the more frequent technological levels and the frequency of beef cattle farms, by homogeneous microregion of the IBGE.

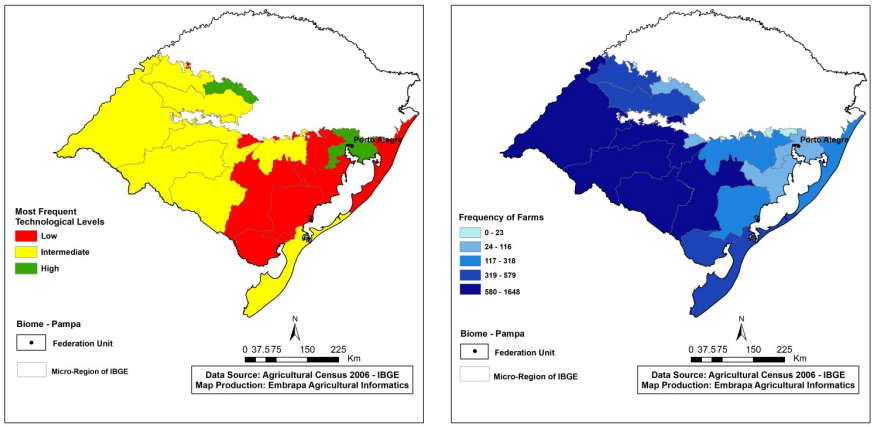

Figure 5. Most frequent technological levels in beef cattle farms and frequency of farms, by homogeneous microregion of IBGE - Pampa.

Caatinga

The Caatinga covers about 11% of Brazilian territory. It is the main ecosystem/biome in Northeast region, and the least known among the country biomes, despite its great biodiversity. It is estimated that 80% of the original ecosystems have been changed, mainly by deforestation - which reaches 46% of the biome - and burning, in a settlement process that began in colonial times. In Brazil, 62% of the areas susceptible to desertification are located in Caatinga, a crucial problem since a high proportion of population is poor and depends on biodiversity to survive (Brasil, 2018c).

Unlike other biomes where pastures (natural or planted) are based on grasses, the native vegetation of Caatinga is characterized by the predominance of shrubs and trees with low forage potential (Santos et al., 2005).

According to the Census of Agriculture – 2006 (IBGE, 2012), Caatinga held 6% of beef farms, 4% of pastureland and 3% of Brazilian beef herd.

Cattle are typically raised in small farms, with 373 ha of pastures holding 171 AU, in average, the lowest values in Brazil. The stocking rate was the second lowest in the country (0.46 AU/ha). These values represent the averages of the farms having 100 heads or more that composed this analysis. Further details of the Caatinga clusters can be found in Appendix 12.

A parity between specialized (in beef cattle) and diversified farms have been found in the biome. The clusters gathering the specialized farms were: a) full cycle systems, intermediate technology (Cluster 2); b) cow-calf as priority, low technology (Cluster 4). The diversified farms were grouped as follows: a) cow-calf and rearing, low technology (Cluster 1); b) cattle finishing, high technology (Cluster 3); c) full cycle, purchasing cattle for finishing, high technology (Cluster 5); d) larger herds in full cycle systems which sell calves and steers, high technology (Cluster 6); and e) farms focused on forestry, raising beef cattle in full-cycle systems, high-tech (Cluster 7). Cluster 8 was not considered for being represented by only two farms. Table 7 summarizes the distribution of farms and beef cattle, according to technological level, per FU of the Caatinga Biome.

Table 7. Distribution of beef cattle farms and cattle distribution according to technological level, by Federation Unit – Caatinga

Federation Unit(1)	Technological level												Total Farms	Total Heads
	High				Low				Intermediate					
	Farms	% of Farms	Heads	% of Heads	Farms	% of Farms	Heads	% of Heads	Farms	% of Farms	Heads	% of Heads		
Alagoas	132	49	28,533	47	73	27	18,316	30	62	23	14,002	23	267	60,851
Bahia	1,090	27	338,686	31	1,449	37	319,968	30	1,426	36	418,385	39	3,965	1,077,039
Ceará	378	44	108,744	39	239	28	65,281	23	248	29	106,407	38	865	280,432
Maranhão	16	39	4,047	33	17	41	5,580	46	8	20	2,566	21	41	12,193
Minas Gerais	46	14	49,316	28	125	39	42,201	24	153	47	83,442	48	324	174,959
Paraíba	319	36	73,945	35	274	31	65,526	31	289	33	71,557	34	882	211,028
Pernambuco	222	39	47,378	38	190	34	44,635	36	155	27	32,264	26	567	124,277
Piauí	322	32	81,763	35	412	41	90,745	39	269	27	62,835	27	1,003	235,343
Rio Grande do Norte	256	41	58,646	37	171	27	41,884	27	197	32	57,082	36	624	157,612
Sergipe	110	30	31,475	32	141	39	29,397	30	113	31	36,954	38	364	97,826
Total	**2,891**	**32**	**822,533**	**34**	**3,091**	**35**	**723,533**	**30**	**2,920**	**33**	**885,494**	**36**	**8,902**	**2,431,560**

Source: Based on data from the Census of Agriculture – 2006 (IBGE, 2012).
(1) More than one biome can be present in a Federation Unit.

In Caatinga, low technology predominates when the frequency of farms is analyzed, and intermediate, when the cattle frequency is considered. In general, the distribution of farms was balanced between the three technological levels. The states of Alagoas, Ceará, Pernambuco and Rio Grande do Norte had the greatest proportions of cattle and farms employing high technology. On the other hand, the states of Maranhão and Piauí stood out for the greatest percentages of cattle and farms under low technology. This balance is illustrated by the maps of Figure 6, showing the most frequent technological levels and the frequency of beef cattle farms in Caatinga, by homogeneous microregions of IBGE.

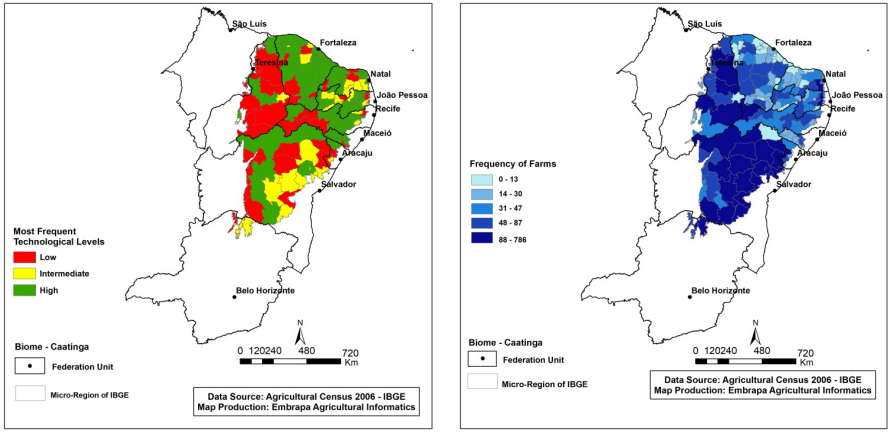

Figure 6. Most frequent technological levels in beef cattle farms and frequency of farms, by homogeneous microregion of IBGE - Caatinga.

Conclusions

This study highlighted the great diversity that characterizes Brazilian beef cattle systems. The data, from over 120,000 farms from the Census of Agriculture - 2006, were used to develop the typology in the six Brazilian biomes. The multivariate analysis classified the beef cattle farms in a consistent way with the national reality, as attested by experts consulted during the focus groups.

As mentioned in this study, the international literature lists several examples of the use of agricultural typologies as tools to support public policy design, extension policies, technical assistance and technology transfer. Moreover, they can support the definition of research priorities, and provide basic data for simulations, exploratory studies and construction of scenarios as a way to analyze adaptation strategies to external shocks. All of them are important tools to support the formulation of public policies.

The present study differentiated the beef cattle production systems in the Brazilian biomes with an emphasis on the technology adoption. The results contributed to the actions of the PECUS Research Network ("Greenhouse Gases Dynamics in Brazilian Livestock Production Systems" Embrapa's Project). The first aim of this research was to identify the technological characteristics of cattle farmers and orientate the execution of technical panels to obtain information regarding production costs for each group. The second aim was to improve regional estimates of greenhouse gases emissions by considering them as a sum of the emissions of the typical production systems with their technical coefficients collected in the technical panels. The third aim was to provide parameters to a land use optimization model for the Brazilian beef cattle production systems. The model allocates the available land for beef cattle production systems in each biome in order to maximize the economic return of national production, respecting environmental restrictions and investment limits. The typology contributed to the model by providing an initial allocation of areas to be occupied for each production system. The model then optimizes the allocation of different land uses (orientating the exchanges between different production systems) to find maximum constrained farm income over time. Moreover, this typology is supporting the simulation of local decisions for land use/cover change models, based on cellular automata and

multi-agent system models, such as described by Valbuena et al. (2008), in order to allocate and account for the inherent diversity of farmers and farm characteristics in rural landscapes.

One recommendation for future studies is to understand the changes occurred in the beef cattle farms during the inter-census period (2006 to 2017). It can be done by comparing the typologies obtained with the data available from the last two censuses of the IBGE. One of the main challenges is to adapt this study to the more limited scope of variables related to the technological adoption in the cattle beef systems that are presented in the Census of Agriculture - 2017.

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Appendices

APPENDIX 1

Correlation matrix (variables x factors), communalities and variability explained (%) - AMAZÔNIA

Variable	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8	Communalities
Percentage of farms having cow-calf	-0.0223	0.6094	0.0469	**0.5179**	0.0074	0.0166	-0.0081	0.0098	0.6428
Percentage of farms having rearing	-0.0179	0.0145	0.0230	**0.9009**	0.0087	-0.0139	0.0233	-0.0121	0.8136
Percentage of farms having finishing	-0.0001	**-0.7558**	0.0960	0.2090	0.0265	0.0288	0.0553	0.0122	0.6288
Percentage of cows in the herd	0.0148	**0.7527**	-0.0027	0.1534	-0.0300	0.0051	0.0807	0.0251	0.5983
Stocking rate (AU/ha)	-0.0093	0.0181	0.0061	-0.0103	0.0106	-0.0043	-0.0078	**0.9862**	0.9734
Percentage of farms using feed suply	0.0516	-0.1949	0.3058	0.0388	0.4261	-0.1019	0.2283	0.0319	0.3808
Percentage of farms using pastures fertilization	-0.0161	0.0149	**0.6107**	-0.0901	0.0330	-0.0223	-0.1385	-0.1157	0.4157
Percentage of farms using advisory services	0.0439	-0.0740	**0.5778**	0.0272	0.0553	-0.0170	0.0541	-0.0378	0.3496
Percentage of cattle in feedlots	-0.0128	0.0396	-0.0693	-0.0094	**0.9226**	0.0451	-0.0861	-0.0062	0.8673
Percentage of cows inseminated	0.0029	0.1365	**0.5902**	-0.0185	-0.0063	0.0361	0.0524	0.0692	0.3762
Percentage of total crops area (by used area)	**0.9332**	0.0043	0.0173	-0.0129	0.0113	-0.0702	-0.0519	0.0037	0.8792
Percentage of pasture area (by used area)	**-0.9253**	-0.0006	0.0089	0.0157	-0.0042	-0.1304	0.0470	0.0146	0.8759
Percentage of planted forests area (by total used area)	0.0526	-0.0158	0.0124	-0.0080	-0.0022	**0.9889**	0.0039	-0.0036	0.9812
Percentage of product gross value coming from beef	-0.0979	0.0408	0.0294	0.0178	-0.0041	0.0096	**0.9553**	-0.0099	0.9253
Total beef cattle per farm (UA / farm)	-0.0395	-0.1624	**0.5423**	0.1537	-0.0514	0.0218	0.0616	0.1016	0.3628
Total variance (%)	11.6%	10.7%	9.7%	7.9%	6.9%	6.8%	6.8%	6.7%	
Cumulative variance (%)	11.6%	22.3%	32.1%	39.9%	46.9%	53.7%	60.4%	67.1%	

Source: Based on data from the Census of Agriculture – 2006 (IBGE, 2012).

APPENDIX 2

Correlation matrix (variables x factors), communalities and variability explained (%) - CERRADO

Variable	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8	Communalities
Percentage of farms having cow-calf	0.0241	0.7511	0.0760	**0.0152**	0.2809	-0.0041	-0.0126	-0.0192	0.6502
Percentage of farms having rearing	0.0382	0.0126	0.0316	**0.0609**	0.8912	-0.0515	0.0003	-0.0199	0.8036
Percentage of farms having finishing	0.0022	**-0.6499**	0.1950	0.0357	0.2996	0.0493	0.0149	0.0174	0.5543
Percentage of cows in the herd	0.0392	**0.7830**	0.0713	-0.0438	-0.0228	0.0256	0.0132	-0.0112	0.6232
Stocking rate (AU/ha)	-0.0519	-0.0048	-0.0182	0.0682	-0.0614	0.9137	-0.0172	**0.0378**	0.8481
Percentage of farms using feed suply	-0.0307	-0.0501	-0.0328	0.7011	0.2224	0.0655	-0.0276	0.1619	0.5768
Percentage of farms using pastures fertilization	0.0231	0.0056	**0.1673**	0.7459	-0.1487	0.0102	0.0299	-0.1073	0.6196
Percentage of farms using advisory services	-0.1305	-0.0761	**0.4813**	0.3492	0.1123	-0.0435	0.0258	-0.0371	0.3930
Percentage of cattle in feedlots	-0.0159	-0.0407	0.0207	0.0274	**-0.0197**	0.0355	0.0044	0.9729	0.9514
Percentage of cows inseminated	-0.0178	0.1310	**0.6605**	0.1426	-0.1330	-0.2231	-0.0243	0.0831	0.5491
Percentage of total crops area (by used area)	**-0.9281**	0.0056	0.0826	0.0631	0.0270	0.1172	-0.0150	0.0469	0.8891
Percentage of pasture area (by used area)	**0.9151**	-0.0204	-0.0629	-0.0301	-0.0208	-0.1040	-0.1600	-0.0689	0.8844
Percentage of planted forests area (by total used area)	-0.0372	-0.0091	-0.0024	0.0074	-0.0005	**-0.0148**	0.9913	0.0036	0.9844
Percentage of product gross value coming from beef	0.4924	0.0860	0.1359	0.0414	0.0898	0.1718	**0.0827**	0.0851	0.3217
Total beef cattle per farm (UA / farm)	0.1273	-0.0759	**0.7135**	-0.1274	0.1321	0.3016	0.0078	-0.0332	0.6568
Total variance (%)	13.2%	10.9%	8.6%	8.2%	7.3%	7.0%	6.8%	6.7%	
Cumulative variance (%)	13.2%	24.2%	32.7%	40.9%	48.2%	55.2%	62.0%	68.7%	

Source: Based on data from the Census of Agriculture – 2006 (IBGE, 2012).

APPENDIX 3

Correlation matrix (variables x factors), communalities and variability explained (%) - MATA ATLÂNTICA

Variable	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8	Communalities
Percentage of farms having cow-calf	0.0011	**0.5810**	-0.0103	**0.5728**	0.0221	0.0551	0.0219	-0.0046	0.6699
Percentage of farms having rearing	0.0464	-0.0052	0.0101	**0.8604**	0.0531	0.0038	-0.0341	-0.0140	0.7467
Percentage of farms having finishing	-0.0158	**-0.7253**	0.1199	0.1676	0.0174	0.1015	0.0543	-0.0256	0.5830
Percentage of cows in the herd	-0.0104	**0.7652**	-0.0094	0.1811	-0.0112	0.0805	0.0537	-0.0042	0.6280
Stocking rate (AU/ha)	0.0013	0.0183	0.0402	-0.0177	0.0137	0.0134	0.0034	**0.9852**	0.9733
Percentage of farms using feed suply	-0.0091	-0.0605	**0.6605**	0.1569	0.3137	0.0125	0.0282	-0.0232	0.5646
Percentage of farms using pastures fertilization	0.0744	0.0256	0.2167	-0.0125	**0.7612**	-0.0524	0.0439	-0.0258	0.6381
Percentage of farms using advisory services	-0.1973	-0.0386	-0.0755	0.0783	**0.6878**	0.2133	-0.0157	0.0454	0.5731
Percentage of cattle in feedlots	-0.1053	-0.0700	**0.8054**	-0.1280	-0.0591	0.0389	-0.0309	0.0610	0.6907
Percentage of cows inseminated	-0.0206	0.2907	0.1108	-0.1496	0.2110	**0.5998**	-0.0041	-0.1248	0.5395
Percentage of total crops area (by used area)	**-0.9323**	-0.0086	0.1659	0.0255	0.0330	0.0408	-0.0453	-0.0121	0.9023
Percentage of pasture area (by used area)	**0.9213**	-0.0019	-0.1526	-0.0207	-0.0127	-0.0361	-0.1801	0.0123	0.9066
Percentage of planted forests area (by total used area)	-0.0575	0.0068	-0.0062	-0.0280	0.0299	-0.0099	**0.9895**	0.0035	0.9843
Percentage of product gross value coming from beef	**0.5190**	-0.0039	0.2687	0.1318	-0.0796	0.1579	0.0563	-0.0263	0.3941
Total beef cattle per farm (UA / farm)	0.0631	-0.1699	-0.0164	0.1291	-0.0064	**0.8148**	-0.0067	0.0993	0.7237
Total variance (%)	13.7%	10.5%	8.6%	8.2%	8.1%	7.5%	6.9%	6.7%	
Cumulative variance (%)	13.7%	24.2%	32.8%	41.0%	49.1%	56.6%	63.4%	70.1%	

Source: Based on data from the Census of Agriculture – 2006 (IBGE, 2012).

APPENDIX 4

Correlation matrix (variables x factors), communalities and variability explained (%) - PANTANAL

Variable	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8	Communalities
Percentage of farms having cow-calf	**0.7482**	-0.1142	0.0345	0.1308	0.3803	0.0373	0.0116	0.0624	0.7411
Percentage of farms having rearing	0.0470	-0.0315	0.0162	0.0605	**0.8423**	0.0625	-0.0937	0.0693	0.7340
Percentage of farms having finishing	**-0.6705**	0.1245	0.1956	0.0684	0.2577	0.1154	-0.0384	0.0690	0.5940
Percentage of cows in the herd	**0.7865**	-0.0357	-0.0137	-0.0568	-0.0002	0.0134	0.0127	-0.0665	0.6280
Stocking rate (AU/ha)	-0.0582	**0.8193**	0.0650	-0.0235	-0.1090	0.0275	0.1068	0.0405	0.7050
Percentage of farms using feed suply	-0.1161	0.1617	**0.6831**	-0.0917	0.1411	0.0599	0.0507	0.0887	0.5486
Percentage of farms using pastures fertilization	-0.0757	0.0915	0.0794	-0.0038	0.0702	-0.0332	0.0178	**0.9489**	0.9272
Percentage of farms using advisory services	0.0024	0.1629	-0.0144	**0.6836**	0.0712	-0.2358	-0.0955	-0.0257	0.5645
Percentage of cows inseminated	0.0125	-0.0213	0.1157	0.4714	-0.0457	**0.5892**	0.0296	0.1994	0.6262
Percentage of pasture area (by used area)	0.0601	0.0457	-0.0659	-0.0038	-0.1126	0.0644	**0.8746**	0.0351	0.7930
Percentage of product gross value coming from beef	-0.0686	-0.2374	0.4724	0.1967	0.2043	-0.1627	0.3651	-0.0996	0.5344
Total beef cattle per farm (UA / farm)	-0.0341	-0.1240	0.0293	**0.7026**	0.0452	0.1336	0.0905	-0.0104	0.5392
Percentage of natural pastures area (by total pastures area)	0.1290	**-0.8285**	-0.0459	-0.0041	-0.0649	-0.1139	0.1230	-0.0713	0.7426
Percentage of degraded sown pastures area (by total pastures area)	-0.0454	0.1353	0.0094	-0.1483	0.0851	**0.7797**	0.0190	-0.1203	0.6725
Percentage of farms that have animals traced	-0.2715	0.3758	0.3291	0.1697	0.3315	-0.0728	0.1325	-0.0666	0.4893
Percentage of cattle in feedlots	0.0375	0.0447	**0.7048**	0.0884	-0.2484	0.1006	-0.3178	0.0607	0.6844
Total variance (%)	11.0%	10.5%	8.5%	8.2%	7.5%	6.9%	6.7%	6.3%	
Cumulative variance (%)	11.0%	21.5%	30.0%	38.3%	45.8%	52.8%	59.5%	65.8%	

Source: Based on data from the Census of Agriculture – 2006 (IBGE, 2012).

APPENDIX 5

Correlation matrix (variables x factors), communalities and variability explained (%) - PAMPA

Variable	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8	Communalities
Percentage of farms having cow-calf	0.0351	**0.6402**	0.0602	-0.0754	0.4389	-0.0324	-0.0260	-0.0112	0.6150
Percentage of farms having rearing	0.0373	0.2262	0.0610	-0.0457	**0.8173**	-0.0300	-0.0404	0.0117	0.7290
Percentage of farms having finishing	0.0077	-0.4957	0.1387	0.0861	**0.5085**	0.0763	0.0224	-0.0367	0.5387
Percentage of cows in the herd	0.0729	**0.7928**	0.0592	-0.0065	0.0018	-0.0530	0.0072	-0.0474	0.6425
Stocking rate (AU/ha)	-0.0364	0.0289	-0.1670	-0.0711	0.1263	**0.5733**	0.1218	-0.1944	0.4323
Percentage of farms using feed suply	0.0460	0.0068	0.4567	0.0775	0.0395	0.4544	-0.0693	0.1569	0.4542
Percentage of farms using pastures fertilization	-0.0143	0.0206	0.4977	-0.0257	-0.0040	0.2735	0.1145	0.2004	0.3770
Percentage of farms using advisory services	-0.2628	-0.0197	**0.5393**	-0.0073	0.0770	-0.0253	-0.0248	-0.0180	0.3678
Percentage of cattle in feedlots	-0.0228	-0.0895	0.0346	0.0541	-0.1201	**0.7294**	-0.0702	0.0346	0.5653
Percentage of cows inseminated	0.0480	0.1737	**0.6361**	0.0231	-0.0336	-0.0588	-0.0019	-0.0382	0.4437
Percentage of pasture area (by used area)	**0.8011**	0.0592	-0.0580	-0.4433	-0.0144	-0.0565	-0.0906	-0.2080	0.9000
Percentage of planted forests area (by total used area)	-0.0710	0.0259	0.0366	-0.0911	-0.1531	0.0102	0.0056	**0.6670**	0.4837
Percentage of product gross value coming from beef	**0.7173**	-0.0714	0.0464	0.1761	0.1192	0.0644	0.0358	0.0935	0.5811
Total beef cattle per farm (UA / farm)	0.0572	-0.0845	**0.6325**	-0.0154	0.1029	-0.1364	0.0427	-0.1719	0.4713
Percentage of steers in the herd	0.0576	**-0.8093**	-0.0403	-0.0478	-0.0475	-0.0329	-0.0018	-0.0195	0.6659
Percentage of natural pastures area (by total pastures area)	0.2530	0.0924	-0.1276	-0.4321	-0.0118	-0.0285	-0.5716	-0.1411	0.6231
Percentage of degraded sown pastures area (by total pastures area)	0.0396	0.0312	0.0007	-0.0984	-0.0385	-0.0030	**0.8934**	-0.0137	0.8121
Percentage of total permanent crops (by total crops area)	0.0257	-0.0455	-0.0854	0.0779	0.1514	-0.0575	0.0375	**0.6629**	0.4832
Percentage of temporary crops (by total crops area)	**-0.8944**	-0.0703	0.0871	0.0532	0.0489	0.0829	0.0574	0.0382	0.8293
Percentage of forages for cutting area (by used area)	-0.0089	0.0075	-0.0289	**0.9113**	-0.0277	0.0072	-0.0241	-0.0608	0.8366
Total variance (%)	10.6%	10.3%	8.3%	6.5%	6.2%	6.0%	5.9%	5.5%	
Cumulative variance (%)	10.6%	20.9%	29.2%	35.7%	41.9%	47.8%	53.8%	59.3%	

Source: Based on data from the Census of Agriculture – 2006 (IBGE, 2012).

APPENDIX 6

Correlation matrix (variables x factors), communalities and variability explained (%) - CAATINGA

Variable	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8	Communalities
Percentage of farms having cow-calf	-0.0246	**0.6705**	-0.0421	0.0572	0.4269	-0.0269	-0.0445	-0.0359	0.6415
Percentage of farms having rearing	-0.0469	-0.0398	0.0506	-0.0490	**0.9047**	-0.0174	0.0242	0.0116	0.8283
Percentage of farms having finishing	0.0355	**-0.7056**	0.0024	0.0518	0.1633	0.0290	0.1787	0.0223	0.5617
Percentage of cows in the herd	0.0369	**0.6946**	0.0329	0.0285	-0.0411	-0.0139	0.1674	0.0462	0.5178
Stocking rate (AU/ha)	-0.0146	0.0110	-0.0456	-0.0635	0.0500	**0.8824**	-0.0790	-0.0300	0.7947
Percentage of farms using feed suply	0.1419	0.0530	0.0787	**0.7219**	0.0315	0.1132	0.1785	0.0572	0.5993
Percentage of farms using pastures fertilization	-0.0396	-0.0044	**0.4946**	0.2903	-0.0044	-0.0740	0.1378	0.1505	0.3776
Percentage of farms using advisory services	0.0363	-0.0477	**0.6209**	0.2299	0.0795	-0.0378	-0.1570	0.0937	0.4832
Percentage of cattle in feedlots	0.0651	-0.1023	0.1229	0.3149	-0.1125	**0.4984**	0.1237	0.0513	0.4080
Percentage of cows inseminated	-0.0002	0.1427	**0.6087**	-0.1695	-0.1364	0.1088	0.0472	-0.0172	0.4526
Percentage of total crops area (by used area)	**0.9149**	-0.0012	-0.0053	0.0164	-0.0480	0.0477	-0.0740	-0.0096	0.8474
Percentage of pasture area (by used area)	**-0.8593**	-0.0424	0.0363	0.0052	0.0479	-0.0654	0.0608	-0.1293	0.7685
Percentage of planted forests area (by total used area)	-0.0074	-0.0021	0.0082	-0.0391	0.0104	0.0074	-0.0379	**0.9392**	0.8853
Percentage of product gross value coming from beef	-0.0738	-0.0178	0.0141	0.0173	0.0119	-0.0020	**0.8922**	-0.0474	0.8047
Total beef cattle per farm (UA / farm)	-0.0458	-0.0959	**0.5457**	-0.1848	0.1366	0.0354	0.0397	-0.2174	0.4120
Percentage of natural pastures area (by total pastures area)	-0.1871	-0.0206	-0.1007	**0.6525**	-0.0829	-0.0200	-0.2993	-0.1657	0.5956
Percentage of forages for cutting area (by used area)	**0.7572**	-0.0464	0.0028	0.0058	0.0275	-0.0638	0.0594	-0.1016	0.5943
Total variance (%)	13.1%	8.7%	7.9%	7.4%	6.5%	6.3%	6.3%	6.1%	
Cumulative variance (%)	13.1%	21.8%	29.7%	37.1%	43.6%	49.9%	56.1%	62.2%	

Source: Based on data from the Census of Agriculture – 2006 (IBGE, 2012).

APPENDIX 7

Main clusters' characteristics of beef cattle farms in the Cerrado biome.

Characteristics	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6	Cluster 7	Average
Production system	Full cycle on pasture	Full cycle on pasture	Rearing-finishing on pasture	Full cycle on pasture, sells calves and steers	Cow-calf on pasture	Full cycle on pasture	Finishing - feedlot	
Farm specialization level	Diversified	Diversified	Specialized	Specialized	Specialized	Diversified	Specialized	
Relative frequency of farms in the biome	0.2%	8.2%	24.9%	45.9%	16.1%	4.6%	0.02%	
Proportion of pasture area in relation to the biome pasture area	0.2%	3.9%	19.8%	43.4%	12.8%	19.9%	0.001%	
Proportion of the herd in relation to the biome herd	0.2%	5.8%	19.3%	41.8%	11.1%	21.6%	0.1%	
Stocking rate (AU/ha)	0.77	1.09	0.72	0.7	0.62	0.82	257.1	0.74
Average pasture area per farm (ha)	783	382	645	767	643	3,534	21	812
Average herd per farm (UA)	606	416	465	537	400	2,909	5,399	597
Percentage of total crops area (by used area)	1.6%	48.7%	1.2%	0.9%	0.7%	5.6%	37.9%	7.2%
Percentage of pasture area (by used area)	27.5%	28.8%	91.3%	91.1%	88.8%	86.4%	3.8%	82.6%
Percentage of forages for cutting area (by used area)	1.8%	6.5%	0.3%	0.3%	0.2%	0.8%	11.2%	1.1%
Percentage of planted forests area (by total used area)	60.3%	0.1%	0.01%	0.2%	0.0%	0.2%	0.0%	0.5%
Percentage of agroforest systems área (by total used area)	1.6%	8.0%	0.8%	1.0%	0.9%	0.9%	0.0%	1.7%
Percentage of farms using feed suply	29.4%	37.9%	30.0%	35.9%	25.4%	44.8%	90.0%	33.3%
Percentage of farms using advisory services	66.1%	67.3%	49.3%	52.1%	40.9%	86.5%	90.0%	52.5%
Percentage of farms using pastures fertilization	11.9%	16.4%	10.4%	14.2%	12.4%	24.7%	30.0%	13.6%
Percentage of farms using crops for pasture recovering	16.5%	22.5%	10.6%	13.4%	13.0%	19.6%	10.0%	13.7%
Percentage of cows inseminated	10.1%	0.9%	0.2%	1.5%	0.7%	23.5%	0.0%	6.1%
Percentage of cows under embryo transfer	0.1%	0.3%	0.1%	0.1%	0.2%	0.9%	0.0%	0.3%
Percentage of cattle in feedlots	9.8%	10.4%	6.8%	1.6%	1.0%	6.6%	100.0%	4.5%
Proportion of product gross value coming from beef	6.7%	10.0%	81.1%	83.2%	82.2%	62.5%	74.8%	51.6%
Average standardized value for technological level	0.5040	1.8620	-0.3810	-0.0820	-0.8950	2.1400	-	
Technological level	High	High	Low	Intermediate	Low	High	High	

Source: Based on data from the Census of Agriculture – 2006 (IBGE, 2012).

APPENDIX 8

Main clusters' characteristics of beef cattle farms in the Pantanal biome.

Characteristics	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6	Cluster 7	Cluster 8	Average
Production system	Cow-calf-rearing on natural pasture	Raring-finishing on pasture	Cow-calf-rearing on natural pasture	Full cycle on pasture (natural + planted)	Cow-calf on pasture	Full cycle on pasture (natural + planted)	Full cycle	Full cycle - feedlot	
Farm specialization level	Specialized	Specialized	Specialized	Specialized	Diversified	Specialized	Specialized	Specialized	
Relative frequency of farms in the biome	39.5%	20.2%	26.5%	7.0%	2.1%	3.1%	1.10%	0.5%	
Proportion of pasture area in relation to the biome pasture area	42.4%	12.1%	21.3%	21.3%	0.6%	1.8%	0.400%	0.1%	
Proportion of the herd in relation to the biome herd	32.3%	13.6%	19.2%	29.1%	1.3%	3.5%	0.8%	0.2%	
Stocking rate (AU/ha)	0.3	0.46	0.36	0.54	0.79	0.72	0.83	1.45	0.40
Average pasture area per farm (ha)	5,750	3,224	4,317	16,316	1,639	3,060	1,871	663	5,361
Average herd per farm (UA)	1,735	1,486	1,557	8,839	1,291	2,202	1,554	959	2,133
Percentage of total crops area (by used area)	0.0%	0.0%	0.0%	0.1%	9.5%	0.6%	0.4%	14.1%	0.2%
Percentage of pasture area (by used area)	93.8%	95.0%	94.3%	85.3%	40.3%	96.3%	77.3%	85.0%	91.3%
Percentage of forages for cutting area (by used area)	0.0%	0.0%	0.0%	0.0%	18.2%	2.4%	0.4%	0.2%	0.3%
Percentage of planted forests area (by total used area)	0.0%	0.0%	0.01%	0.0%	3.9%	0.0%	0.0%	0.0%	0.1%
Percentage of agroforest systems área (by total used area)	0.3%	0.1%	0.0%	0.5%	16.5%	0.0%	0.9%	0.8%	0.5%
Percentage of farms using feed suply	30.9%	16.1%	8.3%	23.3%	15.4%	50.0%	42.9%	83.3%	22.0%
Percentage of farms using advisory services	63.6%	72.6%	59.5%	93.0%	73.1%	78.9%	57.1%	66.7%	67.0%
Percentage of farms using pastures fertilization	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	7.1%	0.0%	3.2%
Percentage of farms using crops for pasture recovering	2.9%	1.6%	1.2%	5.8%	7.7%	15.8%	7.1%	0.0%	2.9%
Percentage of cows inseminated	0.5%	0.6%	0.4%	16.8%	0.0%	12.4%	13.1%	20.5%	5.2%
Percentage of cows under embryo transfer	0.0%	0.0%	0.0%	0.7%	0.0%	1.1%	0.2%	0.0%	0.2%
Percentage of cattle in feedlots	0.3%	0.1%	0.0%	1.9%	0.0%	10.9%	0.8%	56.3%	1.2%
Proportion of product gross value coming from beef	99.4%	99.6%	97.0%	99.7%	72.2%	96.6%	99.9%	99.1%	98.9%
Average standardized value for technological level	-0.1215	-0.0614	-0.5616	0.8393	0.6891	3.0845	0.8980	4.0074	
Technological level	Intermediate	Intermediate	Low	High	High	High	High	High	

Source: Based on data from the Census of Agriculture – 2006 (IBGE, 2012).

APPENDIX 9

Main clusters' characteristics of beef cattle farms in the Amazônia biome.

Characteristics	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6	Average
Production system	Full cycle on pasture	Finishing on pasture	Full cycle on pasture, sells calves	Full cycle on pasture	Full cycle	Full cycle, buy calves	
Farm specialization level	Diversified	Specialized	Specialized	Specialized	Diversified	Specialized	
Relative frequency of farms in the biome	6.5%	18.7%	61.1%	8.7%	4.7%	0.2%	
Proportion of pasture area in relation to the biome pasture area	2.5%	17.6%	59.8%	5.6%	10.3%	4.2%	
Proportion of the herd in relation to the biome herd	4.7%	14.3%	60.0%	5.8%	10.4%	4.8%	
Stocking rate (AU/ha)	1.64	0.73	0.88	0.86	0.88	0.98	0.88
Average pasture area per farm (ha)	271	660	685	451	1,529	14,538	701
Average herd per farm (UA)	445	482	605	389	1,348	14,188	615
Percentage of total crops area (by used area)	29.2%	0.2%	0.6%	0.6%	4.4%	2.8%	2.9%
Percentage of pasture area (by used area)	28.6%	82.3%	82.1%	67.1%	79.6%	83.5%	77.3%
Percentage of forages for cutting area (by used area)	7.7%	0.1%	0.0%	0.0%	1.1%	0.0%	0.7%
Percentage of planted forests area (by total used area)	2.6%	0.0%	0.02%	0.0%	0.0%	0.0%	0.2%
Percentage of agroforest systems área (by total used area)	12.2%	0.3%	0.6%	1.2%	0.6%	1.3%	1.4%
Percentage of farms using feed suply	10.8%	18.7%	9.1%	6.8%	29.0%	36.1%	11.8%
Percentage of farms using advisory services	36.4%	33.7%	31.1%	19.0%	70.8%	73.8%	32.8%
Percentage of farms using pastures fertilization	0.1%	0.0%	0.2%	0.0%	68.6%	19.7%	3.4%
Percentage of farms using crops for pasture recovering	10.6%	6.5%	7.7%	9.6%	19.5%	11.5%	8.4%
Percentage of cows inseminated	1.1%	0.1%	1.6%	0.3%	35.7%	7.4%	5.4%
Percentage of cows under embryo transfer	0.1%	0.0%	0.1%	0.0%	1.1%	0.0%	0.2%
Percentage of cattle in feedlots	2.1%	0.8%	0.8%	0.3%	1.5%	1.8%	1.0%
Proportion of product gross value coming from beef	25.9%	95.8%	93.6%	77.9%	53.4%	90.2%	78.0%
Average standardized value for technological level	1.1869	-0.1424	-0.2721	-0.676	2.8095	2.2551	
Technological level	High	Intermediate	Low	Low	High	High	

Source: Based on data from the Census of Agriculture – 2006 (IBGE, 2012).

APPENDIX 10

Main clusters' characteristics of beef cattle farms in the Mata Atlântica biome.

Characteristics	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6	Cluster 7	Average
Production system	Full cycle on pasture	Finishing on pasture	Full cycle on pasture	Full cycle on pasture	Cow-calf-rearing on pasture	Finishing on pasture and feedlot	Full cycle on pasture	
Farm specialization level	Diversified	Specialized	Diversified	Specialized	Diversified	Diversified	Diversified	
Relative frequency of farms in the biome	12.8%	24.0%	6.2%	35.3%	18.0%	3.2%	0.5%	
Proportion of pasture area in relation to the biome pasture area	6.7%	24.3%	20.1%	32.3%	15.0%	1.7%	0.3%	
Proportion of the herd in relation to the biome herd	9.8%	21.8%	21.8%	30.2%	13.1%	2.8%	0.4%	
Stocking rate (AU/ha)	1.53	0.96	1.16	0.95	0.92	1.74	1.11	1.04
Average pasture area per farm (ha)	216	422	1,360	381	338	229	273	417
Average herd per farm (UA)	330	405	1,574	363	310	397	302	435
Percentage of total crops area (by used area)	48.7%	2.5%	9.4%	2.8%	2.3%	34.6%	3.6%	11.7%
Percentage of pasture area (by used area)	35.3%	92.9%	84.2%	90.6%	91.3%	57.3%	30.6%	80.2%
Percentage of forages for cutting area (by used area)	6.6%	0.4%	2.1%	0.5%	0.3%	3.5%	0.4%	1.8%
Percentage of planted forests area (by total used area)	0.4%	0.0%	0.18%	1.0%	0.1%	0.2%	56.2%	0.9%
Percentage of agroforest systems área (by total used area)	4.0%	0.4%	1.0%	0.8%	0.9%	1.2%	0.6%	1.3%
Percentage of farms using feed suply	32.7%	24.8%	50.0%	39.9%	21.1%	87.6%	42.8%	34.1%
Percentage of farms using advisory services	78.3%	59.1%	90.8%	53.7%	50.5%	63.2%	73.7%	60.3%
Percentage of farms using pastures fertilization	19.5%	19.6%	38.4%	27.0%	11.9%	27.2%	28.9%	22.3%
Percentage of farms using crops for pasture recovering	19.0%	11.0%	25.7%	13.5%	10.5%	16.9%	17.8%	14.0%
Percentage of cows inseminated	1.1%	0.3%	28.6%	0.9%	1.0%	4.6%	7.4%	7.9%
Percentage of cows under embryo transfer	0.2%	0.1%	2.0%	0.2%	0.2%	1.2%	0.0%	0.7%
Percentage of cattle in feedlots	2.9%	1.5%	7.7%	2.6%	0.6%	84.9%	4.6%	5.6%
Proportion of product gross value coming from beef	11.6%	72.8%	63.4%	71.1%	59.4%	51.1%	12.6%	47.3%
Average standardized value for technological level	0.7023	-0.4292	1.6237	-0.0255	-0.8452	2.3661	0.6587	
Technological level	High	Low	High	Intermediate	Low	High	High	

Source: Based on data from the Census of Agriculture – 2006 (IBGE, 2012).

APPENDIX 11

Main clusters' characteristics of beef cattle farms in the Pampa biome.

Characteristics	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6	Cluster 7	Cluster 8	Average
Production system	Finishing on pasture (mainly natural)	Full cycle	Cow-calf-rearing on pasture (mainly natural)	Full cycle on pasture (mainly natural)	Finishing on pasture and feedlot	Full cycle on pasture + forage for cutting	Full cycle on pasture (mainly natural)	Full cycle on recovered planted pasture	
Farm specialization level	Specialized	Diversified	Diversified	Diversified	Diversified	Diversified	Diversified	Diversified	
Relative frequency of farms in the biome	14.7%	11.8%	25.3%	41.4%	1.8%	1.6%	2.20%	1.1%	
Proportion of pasture area in relation to the biome pasture area	13.2%	7.4%	22.7%	52.1%	1.3%	0.5%	1.570%	1.1%	
Proportion of the herd in relation to the biome herd	11.1%	9.5%	21.5%	52.3%	1.6%	1.2%	1.8%	1.1%	
Stocking rate (AU/ha)	0.68	0.94	0.72	0.76	0.89	1.87	0.83	0.73	0.76
Average pasture area per farm (ha)	560	393	560	784	448	190	437	628	623
Average herd per farm (UA)	379	370	401	593	400	375	364	459	473
Percentage of total crops area (by used area)	2.5%	46.1%	9.4%	8.1%	22.0%	18.5%	10.4%	22.0%	13.1%
Percentage of pasture area (by used area)	93.1%	47.6%	85.3%	87.0%	72.3%	30.5%	58.9%	73.2%	80.7%
Percentage of forages for cutting area (by used area)	0.3%	1.1%	0.3%	1.4%	1.0%	48.8%	1.4%	1.0%	1.6%
Percentage of planted forests area (by total used area)	0.1%	0.4%	0.33%	0.3%	0.7%	0.1%	22.6%	1.9%	0.8%
Percentage of agroforest systems área (by total used area)	0.9%	2.0%	1.2%	0.4%	0.7%	1.1%	0.3%	0.4%	0.9%
Percentage of farms using feed suply	12.6%	29.4%	27.0%	33.9%	89.2%	37.7%	29.8%	31.0%	29.4%
Percentage of farms using advisory services	52.4%	86.5%	62.6%	70.3%	66.2%	68.0%	69.6%	72.4%	67.5%
Percentage of farms using pastures fertilization	20.3%	43.1%	37.2%	41.9%	71.2%	27.9%	55.6%	54.0%	38.4%
Percentage of farms using crops for pasture recovering	10.2%	21.2%	15.1%	18.4%	30.2%	15.6%	25.7%	20.7%	17.0%
Percentage of cows inseminated	0.8%	2.8%	13.0%	17.5%	12.7%	7.4%	13.9%	13.6%	14.1%
Percentage of cows under embryo transfer	0.0%	0.0%	0.1%	0.3%	2.7%	0.0%	0.0%	0.0%	0.2%
Percentage of cattle in feedlots	0.2%	0.9%	0.4%	0.8%	57.1%	4.2%	1.6%	1.5%	1.6%
Proportion of product gross value coming from beef	77.9%	18.4%	40.0%	51.6%	49.0%	39.5%	12.7%	35.1%	39.2%
Average standardized value for technological level	-1.2595	0.7742	-0.2963	0.2206	3.4087	1.1068	0.7919	0.5135	
Technological level	Low	High	Low	Intermediate	High	High	High	High	

Source: Based on data from the Census of Agriculture – 2006 (IBGE, 2012).

APPENDIX 12

Main clusters' characteristics of beef cattle farms in the Caatinga biome.

Characteristics	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6	Cluster 7	Average
Production system	Cow-calf-rearing	Full cycle	Finishing	Cow-calf	Full cycle	Full cycle, sells calves and steers	Full cycle	
Farm specialization level	Diversified	Specialized	Specialized	Specialized	Diversified	Diversified	Diversified	
Relative frequency of farms in the biome	18.0%	32.8%	20.9%	16.7%	10.3%	1.1%	0.2%	
Proportion of pasture area in relation to the biome pasture area	17.0%	38.7%	19.8%	16.5%	2.3%	5.7%	0.1%	
Proportion of the herd in relation to the biome herd	15.5%	36.4%	19.3%	14.3%	8.9%	5.4%	0.1%	
Stocking rate (AU/ha)	0.41	0.43	0.46	0.39	0.74 [1]	0.45	0.92	0.46
Average pasture area per farm (ha)	352	440	353	368	201 [1]	1,898	126	373
Average herd per farm (UA)	145	187	163	144	149	852	116	171
Percentage of total crops area (by used area)	5.0%	3.0%	4.7%	2.2%	23.6%	2.9%	10.9%	5.5%
Percentage of pasture area (by used area)	64.8%	73.0%	73.4%	67.2%	15.6%	62.7%	14.1%	64.5%
Percentage of forages for cutting area (by used area)	0.8%	1.0%	1.3%	0.8%	22.2%	0.8%	0.3%	3.0%
Percentage of planted forests area (by total used area)	0.0%	0.0%	0.03%	0.3%	0.0%	0.0%	53.3%	0.2%
Percentage of agroforest systems área (by total used area)	7.9%	5.8%	5.4%	9.7%	14.1%	1.3%	0.1%	7.2%
Percentage of farms using feed suply	13.5%	42.7%	38.1%	39.7%	47.7%	50.0%	53.3%	36.6%
Percentage of farms using advisory services	21.8%	32.6%	29.6%	20.4%	26.9%	79.0%	66.7%	28.0%
Percentage of farms using pastures fertilization	2.1%	12.8%	10.5%	8.3%	4.9%	40.0%	20.0%	9.2%
Percentage of farms using crops for pasture recovering	10.2%	11.6%	12.6%	10.6%	9.7%	29.0%	20.0%	11.4%
Percentage of cows inseminated	0.3%	0.2%	0.4%	0.3%	0.6%	25.4%	9.8%	2.6%
Percentage of cows under embryo transfer	0.1%	0.0%	0.1%	0.0%	0.0%	1.5%	0.0%	0.2%
Percentage of cattle in feedlots	0.2%	1.2%	5.9%	0.9%	1.8%	4.4%	1.8%	2.2%
Proportion of product gross value coming from beef	12.1%	66.3%	54.2%	85.7%	32.8%	37.1%	0.8%	47.5%
Average standardized value for technological level	-1.0451	0.202	0.5011	-0.4297	0.3012	3.872	2.8704	
Technological level	Low	Intermediate	High	Low	High	High	High	

Source: Based on data from the Census of Agriculture – 2006 (IBGE, 2012). ([1]Calculated considering areas with pastures and forage for cutting.)

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